Site: Apples	**Overall Confidence Rating: High**

Background: A total of 641,000 acres are planted in apples in the United states. Organophosphate pesticides (OP) represent 68% of all pesticide usage on this crop with an average of 2.82 applications per year. Analysis of OP usage was conducted for the following five major apple regions: New England (CT, MA, ME, RI, NH, NJ, NY, VT) , North Central (MI and OH), Appalachian-Southern (DE, GA, MD, NC, PA, SC, TN, VA, WV), Western (AZ and CA), and Pacific North. (OR and WA). Insecticide use patterns and key pests vary both between and within regions. In the absence of effective controls, key pests can destroy 50-90% of the crop. Due to low damage threshold levels in apples, biological control is limited to indirect pests (non-fruit feeding) with little contribution against direct pests.

Organophosphate	% Treated		# Applications		Rate (lb AI/A)		PHI (days)	
Pesticides	Max[23]	Avg[23]	Max[21]	Avg[2-11]	Max[21]	Avg[2-11]	Min[21]	Avg
azinphos-methyl	64.7	61.4	4	2.1	3.1	0.8	7	
chlorpyrifos	53	44	NS	1.6	4	1.4	30	
diazinon	6	3	NS	1.6	5	1.2	21	
dimethoate	14.9	7.4	NS	1.3	2.0	0.8	28	
malathion	15	10	NS	1.1	2.3	0.8	21	
methyl parathion	25	18	NS	1.0	2	2.0	21	
phosmet	34	22	NS	2.9	4	1.1	7	

Confidence Rating: H= high confidence = data from several confirming sources; confirmed by personal experience
M = medium confidence = data from only a few sources; may be some conflicting or unconfirmed info.
L = low confidence = data from only one unconfirmed source

Organophosphate Target Pests for Apple in New England Region (Primary pests controlled by the OP's)[6, 9, 17, 18]	
Major	Bug (Tarnished Plant), Aphids (Rosy Apple, Apple, and Spirea), Apple Maggot, Plum Curculio
Moderate	Leafroller (Obliquebanded and Redbanded))
Minor	Fruitworm (Green and Sparganothis), Sawfly (European Apple), Leafhopper (White Apple and Potato), Scale (San Jose), Mite (European Red), Leafminer (Spotted Tentiform)

Major = 20+% of all OP usage on pest; Moderate = 5-20% of all OP usage on pest; Minor =<5% of all OP usage on pest

Organophosphate Target Pests for Apple in North Central Region (Primary pests controlled by the OP's)[7, 10, 16]	
Major	Codling Moth, Apple Maggot
Moderate	Aphid (Green Apple and Rosy Apple), Fruitworm (Green), Leafroller (Fruit Tree, Red Banded, Oblique Banded, and Variegated), Scale (San Jose), Plum Curculio,
Minor	Mites (European Red, Rust, and Two Spotted Spider), Fruit/Bud Moth (Oriental Fruit, Tufted Apple Bud, and Eye-Spotted Bud), Leafminer (), Bug (Tarnished Plant and Stink), Leafhopper (White Apple and Potato), Borer (Dogwood)

Major = 20+% of all OP usage on pest; Moderate = 5-20% of all OP usage on pest; Minor =<5% of all OP usage on pest

Organophosphate Target Pests for Apple in Appalachian-Southern Region (Primary pests controlled by the OP's)[3, 4 ,14, 15]	
Major	Aphid (Rosy Apple, Apple, Spirea and Apple Grain), Codling Moth
Moderate	Leafroller (Red Banded and Oblique Banded), Scale (San Jose), Mites (European Red, Twospotted Spider, and Apple Rust), Bug (Tarnished Plant and Mullein Plant), Leafhopper (White Apple, Rose, and Potato)
Minor	Fruit/Bud Moth (Tufted Apple Bud and Oriental Fruit), Leafminer (Spotted Tentiform), Plum Curculio, Apple Maggot, Fruitworm (Green)

Major = 20+% of all OP usage on pest; Moderate = 5-20% of all OP usage on pest; Minor =<5% of all OP usage on pest

Organophosphate Target Pests for Apple in Western Region (Primary pests controlled by the OP's)[8, 19, 20]	
Major	Aphid (Rosy Apple, Green Apple, and Green Peach), Codling Moth
Moderate	Scale (San Jose, Italian Pear, and Grape Mealybug)
Minor	Mites (European Red, Apple Rust, Pacific Spider, and McDaniel Spider), Borer (Pacific Flatheaded)

Major = 20+% of all OP usage on pest; Moderate = 5-20% of all OP usage on pest; Minor =<5% of all OP usage on pest

Organophosphate Target Pests for Apple in Pacific North Region (Primary pests controlled by the OP's)[2, 11, 12, 13]	
Major	Leafrollers (Pandemis, Oblique Banded, Fruittree, and European), Codling Moth
Moderate	Scale (San Jose and Oystershell), Fruitworm (Green, Speckled Green, and Pyamidal), Apple Maggot, Aphid (Green Apple, Rosy Apple, and Apple Grain), Mites (European Red, Apple Rust, Twospotted Spider, and McDaniel Spider)
Minor	

Major = 20+% of all OP usage on pest; Moderate = 5-20% of all OP usage on pest; Minor =<5% of all OP usage on pest

Sources:

1. Proprietary EPA market share information.
2. U.S. Apple QUA+ - Washington. 1997.
3. U.S. Apple QUA+ - Virginia, West Virginia. 1997.
4. U.S. Apple QUA+ - Georgia, North Carolina, South Carolina and Tennessee. 1997.
5. U.S. Apple QUA+ - Pennsylvania. 1997.
6. U.S. Apple QUA+ - New England. 1997.
7. U.S. Apple QUA+ - Michigan. 1997.
8. U.S. Apple QUA+ - California. 1997.
9. QUA+ - New England Fruit Consultants.
10. QUA+ Michigan Apple Commission. 1997
11. QUA+ - Northwest Horticultural Council. 1997.
12. Orchard Pest Management; A Resource Book for the Pacific Northwest.1993. Good Fruit Grower, Yakima, WA.
13. Pacific Northwest 1998 Insect Control Handbook. 1998. Oregon State University.
14. 1997 Spray Bulletin for Commercial Tree Fruit Growers. Virginia, West Virginia and Maryland Cooperative Extension.
15. Pennsylvania Tree Fruit Production Guide. 1996-1997. College of Agricultural Science, Penn State University.
16. 1997 Fruit Spraying Calendar for Commercial Fruit Growers. 1997. Bulletin E-154. Michigan State University Extension.
17. Pest Management Recommendations for Commercial Tree Fruit Production. 1997. Cornell University.
18. 1996-1997 New England Apple Pest Management Guide. Cooperative Extension (Universities. of Connecticut, New Hampshire, Maine, Rhode Island, Massachusetts and Vermont)
19. Apple Pest Management Guidelines. 1996. UCPMG Publication 12. IPM Education and Publications, Univ. - CA, Davis
20. Integrated Pest Management for Apples and Pears. 1991. Publication 3340. University of California.
21. Label Use Information System (LUIS) Version 5.0, EPA.
22. The All-Crop, Quick Reference Insect Control Guide (1997), Meister Publishing Company
23. EPA Crop Profile QUA.

Date: 01/28/99

Site: Apple
Region: New England (Including: CT, MA, ME, RI, NH, NJ, NY, VT)

Pest[2, 3, 4, 5, 8]	Organophosphate[1, 2, 3, 4, 5, 8]	Efficacy[4, 5]	Mkt[1]	Class	Alt. Pesticide List[1, 2, 3, 4, 5, 8]	Efficacy[4, 5]	Mkt[1]	Constraints of Alternatives[2, 3, 8]
Timing: Pre-Bloom								
Tarnished Plant Bug (Major)	azinphos-methyl	●	High	Ca	carbaryl	●	---	**Permethrin** would harm aphid and mite predators and cause explosion in mite populations. Continued use of permethrin would lead to resistance bug populations.
	chlorpyrifos	●	Lo	Ca	methomyl	●	---	
	dimethoate	❍ - ☺	Lo	Ca	oxamyl	●	---	
	malathion	●	---	P	esfenvalerate	☺	Med	
	methyl parathion	●	---	P	permethrin	☺	High	
	phosmet	●	Lo	CH	endosulfan	❍	Lo	
Aphid (Rosy Apple) (Major)	azinphos-methyl	●	Med	Ca	carbaryl	●	---	Alternatives as good or better than chlorpyrifos for Rosy Apple Aphid but not other species. **Permethrin** would harm aphid and mite predators and cause explosion in mite populations. Continued permethrin use would lead to pest resistance.
	chlorpyrifos	❍ - ☺	High	Ca	methomyl	● - ❍	Lo	
	diazinon	● - ❍	---	Ca	oxamyl	❍	Lo	
	dimethoate	❍	Lo	P	esfenvalerate	❍ - ☺	Med	
	malathion	● - ❍	---	P	permethrin	❍ - ☺	Lo	
	methyl parathion	●	---	CH	endosulfan	❍ - ☺	High	
	phosmet	●	Lo	O	imidicloprid	● - ☺	---	
Leafroller (Oblique-banded and Red-banded) (Moderate)	azinphos-methyl	● - ☺	Med	Ca	carbaryl	●	---	Permethrin would harm aphid and mite predators and cause explosion in mite populations. Continued use would lead to resistant populations.
	chlorpyrifos	☺	Med	Ca	methomyl	☺	High	
	malathion	● - ❍	Lo	P	esfenvalerate	❍ - ☺	Med	
	methyl parathion	☺	---	P	permethrin	❍ - ☺	Med	
	phosmet	● - ☺	Med	CH	endosulfan	❍	Lo	
				B	Bacillus thuringiensis	☺	---	

Pest Importance: Major = 20+% of all OP usage on pest; Moderate = 5-20% of all OP usage on pest; Minor = <5% of all OP usage on pest
Efficacy Rating: Excellent = ☺ Good = ❍ Fair = ● --- = Not rated for efficacy in state recs.
Market Share: High = 20+% OP of all usage on pest; Med = 5-20% of all usage on pest; Lo = <5% of all usage on pest, --- = not available for 1994-96.
Insecticides: C = Carbamates; P = Pyrethroids; CH = Chlorinated Hydrocarbons; IGR = Insect Growth Regulators; B = Biological; O = Other pesticides

Site: Apple
Region: New England (Including: CT, MA, ME, RI, NH, NJ, NY, VT)

Pest[2, 3, 4, 5, 8]	Organophosphate[1, 2, 3, 4, 5, 8]	Efficacy[4, 5]	Mkt[1]	Class	Alt. Pesticide List[1, 2, 3, 4, 5, 8]	Efficacy[4, 5]	Mkt[1]	Constraints of Alternatives[2, 3, 8]
Timing: Pre-Bloom								
Scale (San Jose)	azinphos-methyl	---	Lo	CH	endosulfan	---	Lo	**Crop oil** is only Moderately effective against San Jose Scale.
	chlorpyrifos	---	High	O	petroleum oil	---	High	
(Minor)	phosmet		High					

ADDITIONAL INFORMATION:

Apple production in the New England Region (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont) accounts for 17.9% of total acreage and 12.7 % of production for the US. OP usage represents 37.1% of all pesticide usage during the Pre-Bloom period in the New England Region.

SOURCES:

1. Proprietary EPA market share information.
2. U.S. Apple QUA+ - New England. 1997.
3. New England Fruit Consultants.
4. Pest Management Recommendations for Commercial Tree Fruit Production. 1997. Cornell University.
5. 1996-1997 New England Apple Pest Management Guide. Cooperative Extension (Univ. of Connecticut, New Hampshire, Maine, Rhode Island, Massachusetts and Vermont)
6. The All-Crop, Quick Reference Insect Control Guide (1997), Meister Publishing Company.
7. Label Use Information System (LUIS) Version 5.0, EPA.
8. Communications with New England Extension Personnel and Apple Producers.

Date: 01/28/99

Pest Importance: Major = 20+% of all OP usage on pest; Moderate = 5-20% of all OP usage on pest; Minor = <5% of all OP usage on pest
Efficacy Rating: Excellent = ☺ Good = ❍ Fair = ● --- = Not rated for efficacy in state recs.
Market Share: High = 20+% OP of all usage on pest; Med = 5-20% of all usage on pest; Lo = <5% of all usage on pest, --- = not available for 1994-96.
Insecticides: C = Carbamates; P = Pyrethroids; CH = Chlorinated Hydrocarbons; IGR = Insect Growth Regulators; B = Biological; O = Other pesticides

Site: Apple
Region: New England (Including: CT, MA, ME, RI, NH, NJ, NY, VT)

Pest[2-5, 8]	Organophosphate[1-5, 8]	Efficacy[4, 5]	Mkt[1]	Class	Alt. Pesticide List[1-5, 8]	Efficacy[4, 5]	Mkt[1]	Constraints of Alternatives[2, 3, 8]
Timing: Post-Bloom								
Apple Maggot (Major)	azinphos-methyl	☺	High	C	carbaryl	☺	Lo	**Pyrethroids** are disruptive to IPM practices and would result in mite explosions and resistant pest populations. **Carbamates** are also disruptive to established IPM programs. In addition, both carbaryl and methomyl have low resisdual activity against adults and would require 1-2 more applications than OP's.
	chlorpyrifos	☺	Lo	C	methomyl	❍	Lo	
	diazinon	☺	Lo	P	esfenvalerate	☺	Lo	
	dimethoate	☺	Lo	P	permethrin	---	Lo	
	malathion	❍	Lo					
	parathion	☺	Lo					
	phosmet	☺	High					
Plum Curculio (Major)	azinphos-methyl	☺	High	C	carbaryl	❍	Lo	**Pyrethroids** are disruptive to IPM practices and would result in mite explosions. Esfenvalerate would disrupt resistance management programs (i.e. acaricides would become useless due to increased usage to control esfenvalerate-induced mite outbreaks. **Carbamates** are also disruptive to established IPM programs. In addition, both carbaryl and methomyl are weak on curculio due to limited persistance against adults. In addition, carbaryl is a strong-Moderate fruit thinner and use is limited to one application after fruit set.
	chlorpyrifos	☺	Med	C	methomyl	❍	Lo	
	diazinon	❍	Lo	P	esfenvalerate	☺	Lo	
	dimethoate	❍	Lo	P	permethrin	---	Lo	
	parathion-methyl	☺	Lo					
	phosmet	☺	High					

Pest Importance: Major = 20+% of all OP usage on pest; Moderate = 5-20% of all OP usage on pest; Minor = <5% of all OP usage on pest
Efficacy Rating: Excellent = ☺ Good = ❍ Fair = ● --- = Not rated for efficacy in state recs.
Market Share: High = 20+% OP usage on pest; Med = 5-20% of all usage on pest; Lo = <5% of all usage on pest; --- = not available for 1994-96.
Insecticides: C = Carbamates; P = Pyrethroids; CH = Chlorinated Hydrocarbons; IGR = Insect Growth Regulators; B = Biological; O = Other pesticide

Site: Apple
Region: New England (Including: CT, MA, ME, RI, NH, NJ, NY, VT)

Pest[2-5, 8]	Organophosphate[1-5, 8]	Efficacy[4, 5]	Mkt[1]	Class	Alt. Pesticide List[1-5, 8]	Efficacy[4, 5]	Mkt[1]	Constraints of Alternatives[2, 3, 8]
Timing: Post-Bloom								
Leafroller (Oblique-banded and Red-banded) (Moderate)	azinphos-methyl	● - ☺	High	C	carbaryl	●	Lo	**OP's** have relegated this pest to secondary status. Loss of OP's could lead to resurgance as a major pest. **Pyrethroids** would disrupt natural or induced predators of mite and would disrupt resistance management programs, i.e., acaricides would rapidly become useless due to increased usage to control pyrethroid-induced mite outbreaks. **Bt** adequate but expensive and rapidly inactivated by UV light. resistance.
	chlorpyrifos	☺	High	C	methomyl	☺	Med	
	malathion	● - ❍	Lo	P	esfenvalerate	❍ - ☺	Lo	
	parathion-methyl	☺	Med	P	permethrin	❍	Lo	
	phosmet	● - ☺	Lo	CH	endosulfan	❍	Med	
				B	azadirachtin	---	Lo	
				B	Bacillus thuringiensis	☺	Lo	
Fruitworm (Green) (Minor)	azinphos-methyl	●	High	C	carbaryl	●	Lo	**Esfenvalerate** is very effective but highly disruptive to IPM.. **Endosulfan** and **Bt** only Moderately effective against high populations
	chlorpyrifos	☺	Lo	C	methomyl	☺	Lo	
	dimethoate	❍	Med	P	esfenvalerate	☺	Lo	
	malathion	●	Lo	P	permethrin	☺	Lo	
	parathion-methyl	❍	Lo	CH	endosulfan	☺	Lo	
	phosmet	●	Lo	B	Bacillus thuringiens	---	---	

Pest Importance: Major = 20+% of all OP usage on pest; Moderate = 5-20% of all OP usage on pest; Minor = <5% of all OP usage on pest
Efficacy Rating: Excellent = ☺ Good = ❍ Fair = ● --- = Not rated for efficacy in state recs.
Market Share: High = 20+% OP usage on pest; Med = 5-20% of all usage on pest; Lo = <5% of all usage on pest; --- = not available for 1994-96.
Insecticides: C = Carbamates; P = Pyrethroids; CH = Chlorinated Hydrocarbons; IGR = Insect Growth Regulators; B = Biological; O = Other pesticide

Site: Apple
Region: New England (Including: CT, MA, ME, RI, NH, NJ, NY, VT)

Pest[2-5, 8]	Organophosphate[1-5, 8]	Efficacy[4, 5]	Mkt[1]	Class	Alt. Pesticide List[1-5, 8]	Efficacy[4, 5]	Mkt[1]	Constraints of Alternatives[2, 3, 8]
Timing: Post-Bloom								
Sawfly (European Apple) (Minor)	azinphos-methyl	☺	High	C	carbaryl	❍	Lo	**Pyrethroids** would harm aphid and mite predators and cause explosion in mite populations. Continued use would lead to resistance. **Carbamates** are generally harsh on natural enemies of mite pests.
	chlorpyrifos	☺	Lo	C	methomyl	❍	Lo	
	diazinon	☺	Lo	P	esfenvalerate	☺	Lo	
	parathion	☺	Lo	P	permethrin	☺	High	
	phosmet	☺	Med					
Leafhopper (White Apple and Potato) (Minor)	azinphos-methyl	●	High	C	carbaryl	☺	Med	
	chlorpyrifos	●	Med	C	methomyl	☺	Med	
	diazinon	●	Lo	C	oxamyl	❍	Lo	
	dimethoate	☺	Med	P	esfenvalerate	☺	Lo	
	malathion	●	Lo	CH	endosulfan	☺	Lo	
	parathion-methyl	●	Lo	O	abamectin	❍		
	phosmet	●	Lo	O	formetanate hydrochloride	☺	Lo	

ADDITIONAL INFORMATION:

Apple production in the New England Region (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont) accounts for 17.9% of total acreage and 12.7 % of production for the US. OP usage represents 68.8% of all pesticide usage during the Pre-Bloom period in the New England Region.

New England fruit growers have since the 1970's readily adopted Integrated Pest Management pratices. Many growers have moved beyond the first stages of IPM to a more bio-intensive level, using more cultural and biological practices to limit insect and disease damage.

Plum Curculio is the most significant fruit insect pest in New England and the most difficult to control. No material other than OP's provide acceptable commercial control. Despite intensive study at UMASS (Amherst) for the past 20 years, no IPM strategies have been identified which are effective against Plum Curculio. Without an effective alternative control agent for Plum Curculio, commercial apple production in the Northeast would be impossible within 3-5 years. There are many other insecticides which can control Plum Curculio but over the years have demonstrated a negative long lasting impact on the predators and beneficial organisms which control later season apple

Pest Importance: Major = 20+% of all OP usage on pest; Moderate = 5-20% of all OP usage on pest; Minor = <5% of all OP usage on pest
Efficacy Rating: Excellent = ☺ Good = ❍ Fair = ● --- = Not rated for efficacy in state recs.
Market Share: High = 20+% OP usage on pest; Med = 5-20% of all usage on pest; Lo = <5% of all usage on pest; --- = not available for 1994-96.
Insecticides: C = Carbamates; P = Pyrethroids; CH = Chlorinated Hydrocarbons; IGR = Insect Growth Regulators; B = Biological; O = Other pesticide

Site: Apple
Region: New England (Including: CT, MA, ME, RI, NH, NJ, NY, VT)

pests. Using these insecticides, particularly Pyrethroids, would guarantee more late season chemical sprays to control insects that in most orchards have been controlled for years biologically.

Apple Maggot is easier to control than Plum Curculio, however, the overall situation is similar. Due to the behavior and life cycle of this pest, half rates of OP at extended intervals are very effective. Once Plum Cuculio season has passed in late May, 2-3 OP applications at 3 week intervals will provide control for the balance of the growing season into September. In addition, cultural practices such as border spraying and alternate row spraying can reduce the amount of chemical used for control. Work is now in progress to test traps (OP treated red sphere) for control effectiveness. Nevertheless, OP's are still necessary for commercial production with no effective alternatives available at this time.
Without new alternatives to OP's, progress made in implementing bio-intensive insect management would be lost with a net result of an increase in pesticide use.

SOURCES:
1. Proprietary EPA market share information.
2. U.S. Apple QUA+ - New England. 1997.
3. New England Fruit Consultants.
4. Pest Management Recommendations for Commercial Tree Fruit Production. 1997. Cornell University.
5. 1996-1997 New England Apple Pest Management Guide. Cooperative Extension (Univ. of Connecticut, New Hampshire, Maine, Rhode Island, Massachusetts and Vermont)
6. The All-Crop, Quick Reference Insect Control Guide (1997), Meister Publishing Company.
7. Label Use Information System (LUIS) Version 5.0, EPA.
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